October 15th, 2024

MuCol WP2 meeting

Take-aways from the Geant4 Collaboration Meeting

October 7-11th, Catania: Indico

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Introduction

Last week I attended the 29th Geant4 Collaboration Meeting
presenting relevant aspects of detector simulation for the Muon Collider

All participants were members of the Geant4 Collaboration

I was the only "outsider" explicitly invited by Soon Yung Jun
to build tighter communication with IMCC as a user and potential contributor

General impression

Geant4 is a very complex toolset under continuous development on multiple aspects:

- **expansion of applications** (HEP, cosmology, nuclear, medical, space)
  - physics description, geometry/material definitions
- **improvement of performance**
  - parallelisation, FastSim, ML integration
  - interfaces with external tools for GPU acceleration (Opticks, AdePT, Celeritas)

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Big LHC experiments are fighting for fairly moderate performance improvements

- **5-10% CPU-time reduction is considered huge**
- **power consumption is a relevant parameter:** CPU-time not equivalent GPU-time

Selected messages

1. Key4hep seems to be not as future-proof as we might think

Explicit funding finished with AIDA-2020 and now dedicated manpower is limited

Big experiments would likely switch to a better-performing alternative as soon as their demands increase

We should keep an eye on these dynamics
and **focus more on the components of Key4hep that fit our use-case in longer term**

Selected messages

2. DD4hep seems to be the weakest component

Geant4 community in general is rather skeptical about it

- inefficient building of geometry with a limited set of shapes
- conversion via the outdated ROOT.TGeo keeps a 2nd version in memory
- extra layers of abstraction complicate adoption of newer Geant4 versions

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CMS uses DD4hep only for geometry description
deleting all DD4hep-specific objects from memory after passing it to Geant4

ATLAS uses their custom GeoModel tool
that has been converted into an experiment-agnostic toolkit

Selected messages

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- extra layers of abstraction complicate adoption of newer Geant4 versions
- DD4hep doesn’t benefit from multithreading in Geant4

DDG4 itself seems to support multithreading according to the documentation
but not the **ddsim** which puts together a configurable Geant4 application

The Issue with multithreading support seems stuck since March 2024
↳ **we might want to have our custom application** built manually from DDG4 components

Selected messages

3. Geant4 supports FLUKA physics models starting from v10.2

With FLUKA installed it is possible to import FLUKA models into Geant4 application
↳ might be useful in some specific use cases (probably not under DD4hep)

Selected messages

4. We should stop using QGSP_BERT physics list

For ~10 years the recommended physics lists for HEP experiments has been **FTFP_BERT_***

Due to this QGSP_* physics lists are considered as experimental by Geant4 developers, where they test new features expecting little impact on users

- QGSP_BERT_HP has a bug in version 10.2
  ↳ safe to use under 10.1 or 10.3

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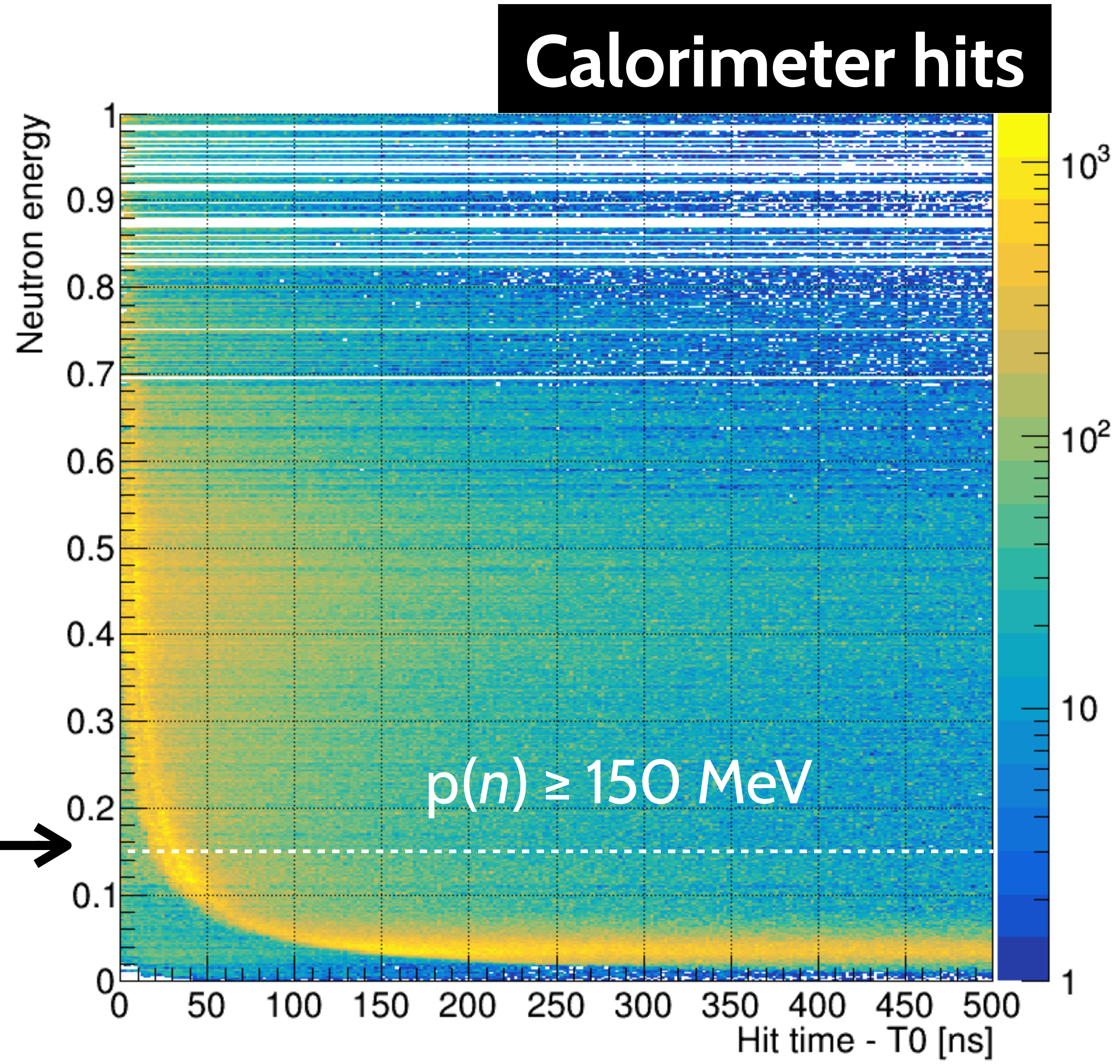
We should not be affected by this in our last release
as we don't use High Precision physics list
due to cutting away low-energy neutrons

This cut has to be reassessed and optimised
with the new detector geometries and BIB samples



Selected messages

5. Woodcock tracking is something to keep an eye on

So far it’s a custom patch in Geant4 code that ignores geometry boundaries, which is illegal for a standard simulation sequence.

It significantly speeds up tracking of photons in calorimeters with high spatial granularity

↳ we have photons as the most abundant BIB component and high-granularity CriLin